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Citation for published version:

Essi, F, Latombe, G, Lenzner, B, Pagad, S, Seebens, H, Smith, K, Wilson, JRU & Genovesi, P 2020, 'The Convention on Biological Diversity (CBD)'s Post-2020 target on invasive alien species – what should it include and how should it be monitored?', *NeoBiota*, vol. 62, pp. 99-121.
<https://doi.org/10.3897/neobiota.62.53972>

Digital Object Identifier (DOI):

[10.3897/neobiota.62.53972](https://doi.org/10.3897/neobiota.62.53972)

Link:

[Link to publication record in Edinburgh Research Explorer](#)

Document Version:

Publisher's PDF, also known as Version of record

Published In:

NeoBiota

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The Convention on Biological Diversity (CBD)'s Post-2020 target on invasive alien species – what should it include and how should it be monitored?*

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Academic editor: J. L. Lockwood | Received 6 May 2020 | Accepted 22 August 2020 | Published 15 October 2020

Citation: Essl F, Latombe G, Lenzner B, Pagad S, Seebens H, Smith K, Wilson JR, Genovesi P (2020) The Convention on Biological Diversity (CBD)'s Post-2020 target on invasive alien species – what should it include and how should it be monitored? In: Wilson JR, Bacher S, Daehler CC, Groom QJ, Kumschick S, Lockwood JL, Robinson TB, Zenggeya TA, Richardson DM (Eds) *Frameworks used in Invasion Science*. NeoBiota 62: 99–121. <https://doi.org/10.3897/neobiota.62.53972>

Abstract

The year 2020 and the next few years are critical for the development of the global biodiversity policy agenda until the mid-21st century, with countries agreeing to a Post-2020 Global Biodiversity Framework under the Convention on Biological Diversity (CBD). Reducing the substantial and still rising impacts of invasive alien species (IAS) on biodiversity will be essential if we are to meet the 2050 Vision where biodiversity is valued, conserved, and restored. A tentative target has been developed by the IUCN Invasive Species Specialist Group (ISSG), and formally submitted to the CBD for consideration in the discussion on the Post-2020 targets. Here, we present properties of this proposal that we regard as essential for an effective Post-2020 Framework. The target should explicitly consider the three main components of biological invasions, i.e. (i) pathways, (ii) species, and (iii) sites; the target should also be (iv) quantitative, (v) supple-

* The opinions given herein belong solely to the authors and do not represent the views or policies of IUCN nor do they replace IUCN's evolving position on the Post-2020 Global Biodiversity Framework.

mented by a set of indicators that can be applied to track progress, and (vi) evaluated at medium- (2030) and long-term (2050) time horizons. We also present a proposed set of indicators to track progress. These properties and indicators are based on the increasing scientific understanding of biological invasions and effectiveness of responses. Achieving an ambitious action-oriented target so that the 2050 Vision can be achieved will require substantial effort and resources, and the cooperation of a wide range of stakeholders.

Keywords

biological invasions, conservation policy, Convention on Biological Diversity (CBD), policy targets, sustainable development

Introduction

Invasive alien species (IAS, see Box 1 for definitions used in this manuscript) are one of the main drivers of global change (Lockwood et al. 2007; Simberloff et al. 2013). They are a major cause of biodiversity loss (Maxwell et al. 2016; Díaz et al. 2019; IPBES 2019), especially on islands (e.g. Bellard et al. 2016; Spatz et al. 2017; Butchart et al. 2018), and cause substantial negative impacts on human health (Mazza et al. 2014, Mazza and Tricarico 2018), livelihoods (Vilà et al. 2010; Pratt et al. 2017), and economies (Bradshaw et al. 2016).

The number of new introductions of species to areas outside their natural range is growing at an unprecedented pace, among all taxonomic groups, and on all continents, with no sign of saturation (Seebens et al. 2017). A high proportion of recent introductions are species that have never been recorded as alien before, meaning that the number of IAS is forecasted to increase in the future among all taxonomic groups and regions (Seebens et al. 2018). In addition, climate change will cause many regions to become more suitable for a greater number of IAS (Bellard et al. 2013), and an increase in extreme weather events will likely facilitate their spread (Diez et al. 2012). Given that there is a close correlation between numbers of established alien species and those causing impacts (Essl et al. 2019), the impacts caused by IAS are expected to continue to increase.

In 2010, Parties to the Convention on Biological Diversity of the United Nations (CBD) adopted the Strategic Plan for Biodiversity 2011–2020, with 20 targets (“Aichi Targets”), including one on IAS: Aichi Target 9 aims that “*By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated and measures are in place to manage pathways to prevent their introduction and establishment*”. The evidence so far shows that while there has been some progress, for example on eradications and pathway management (CBD 2018), overall efforts to meet this target have been largely inadequate (Tittensor et al. 2014). Parties to the CBD are now negotiating a Post-2020 global biodiversity framework and targets, which will aim to bring about a fundamental change in societies’ relationships with nature.

Here, we discuss properties that we regard as essential for a new target on IAS for the Post-2020 Framework. A proposed target based on these properties was developed by the IUCN Invasive Species Specialist Group (ISSG), and submitted in 2019 to the CBD as a contribution to the discussion on the Post-2020 targets (Box 2).

Box 1. Definitions of terms used.

The definitions used in this manuscript and the wording of the targets are, wherever possible, aligned with the terminology used by the CBD, noting that some of the terms are used slightly differently in different contexts. For example, biological invasions are a population level phenomenon, though such invasions are often referred to as “invasive alien species”, rather than invasive alien populations; a commonly used definition of “invasive alien species” does not require impact (Blackburn et al. 2011); and “introduction” is often defined in terms of the human-mediated process of moving propagules to a site where the species to which they belong is not native, without specifying whether there is evidence that such a species has escaped or been released from captivity or cultivation. There is uncertainty in each of the definitions, and it is important that this is specified (e.g. for whether something is alien or native see Essl et al. 2018).

- **Control** refers to management measures that are applied to established IAS over the long term that successfully reduce the impacts from the IAS to desired (and measurable) levels.

- **Effectively managed** pathways of introduction refer to measures that are put in place that successfully prevent the introduction of IAS that cause significant impacts. For example, treatment of ballast water, biosecurity, and rapid detection and eradication capacity.

- **Effectively preventing impacts in vulnerable areas** refers to the establishment of effective management programs that control, or where feasible eradicate IAS, and prevent their introduction.

- **EICAT and SEICAT** are the Environmental Impact Classification of Alien Taxa (EICAT) and the Socio-economic Impact Classification of Alien Taxa (SEICAT) schemes developed by the IUCN ISSG (as requested by Parties to the CBD). The schemes use current known records of impact to develop a standardised impact score for each IAS.

- **Eradicate** refers to management measures that are applied to established IAS that remove all individuals from an area, where there is no chance of re-introduction.

- **Harmful IAS** refers to IAS that cause, or have the potential to cause, substantial environmental and/or socio-economic impacts within the boundaries of a country. Substantial impacts can be defined as those that cause moderate, major or massive impacts under the EICAT or SEICAT schemes.

- **Invasive Alien Species (IAS)** refer to species introduced to areas outside their native range that have become successfully established and cause substantial impacts on the new environment (CBD 2002).

- **Introduction** refers to the introduction of alien species to sites outside of captivity or cultivation and does not include species that may already be alien and introduced within a country but are only found in captivity or in gardens etc.

- **Regulated** refers to the adoption and enforcement of national or regional legislation that results in the prevention and effective management of IAS, in particular through: the development of lists of IAS whose import, transport, possession, and trade are restricted; the establishment of a biosecurity framework; and the introduction of an obligation to control and/or eradicate priority IAS.

- **SEICAT** (see **EICAT**)

- **Significant pathways of introduction** are those pathways that facilitate the introduction of known and potentially harmful IAS within national or subnational boundaries.

- **Vulnerable areas** are geographically defined areas that are important for the persistence of biodiversity and sensitive and susceptible to impacts from IAS. For example, islands, protected areas, and Key Biodiversity Areas.

Box 2. ISSG initial proposal for an invasive alien species target in the Post-2020 biodiversity framework.

The IAS target initially proposed by the IUCN Invasive Species Specialist Group (ISSG) in 2019 was (Figure 2):

Halting the loss of biodiversity caused by invasive alien species by 2030, by preventing their impacts in [100% of] the most vulnerable areas, regulating [50% of] the most harmful invasive alien species, and effectively managing [50% of] the most significant pathways of introduction, such that their impacts are reversed through restoration and recovery by 2050.

This proposal was incorporated, with some changes, in the draft discussed by the CBD's Open Ended Working Group on the Post-2020 Global Biodiversity Framework (WG2020) (<https://www.cbd.int/doc/c/efb0/1f84/a892b98d-2982a829962b6371/wg2020-02-03-en.pdf>). The WG2020 met in February 2020 in Rome and several proposals for improvement of the target have been proposed (<https://www.cbd.int/doc/c/9a1b/c778/8e3ea4d851b7770b59d5a524/wg2020-02-1-02-en.pdf>). IUCN views and suggestions for amendments to the 'zero draft' IAS target have been transmitted to the CBD, including with the option to replace the numerical thresholds with "*to the extent necessary for achieving the Goals*", in order to set the level of ambition for the target at the extent necessary for delivering the Goals, and to highlight "priority" invasive alien species and reduction of their "harmful" impacts. The discussion on the post-2020 targets is still ongoing, and the ISSG will continue to engage in the process using the principles set out in this paper. However, the political discussion so far conducted confirms the general agreement that the Post-2020 Framework shall include a target on IAS, which should be consistent with the key principles summarised in this article.

We also provide further justification for the continuing process of developing the IAS target, based on scientific evidence and extensive policy experience (Figure 1). The properties we regard as essential for such a target are that it:

- (i–iii) explicitly considers the three main components of the phenomenon of biological invasions, i.e. (i) pathways, (ii) species, and (iii) sites (McGeoch et al. 2016);
- (iv) is quantitative, i.e. numerical goals and timelines are provided;
- (v) is supplemented by a set of indicators that can be applied to track progress; and that it
- (vi) can be evaluated at medium- (2030) and long-term (2050) time horizons.

Policy background

The recent global assessment on biodiversity and ecosystem services by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)

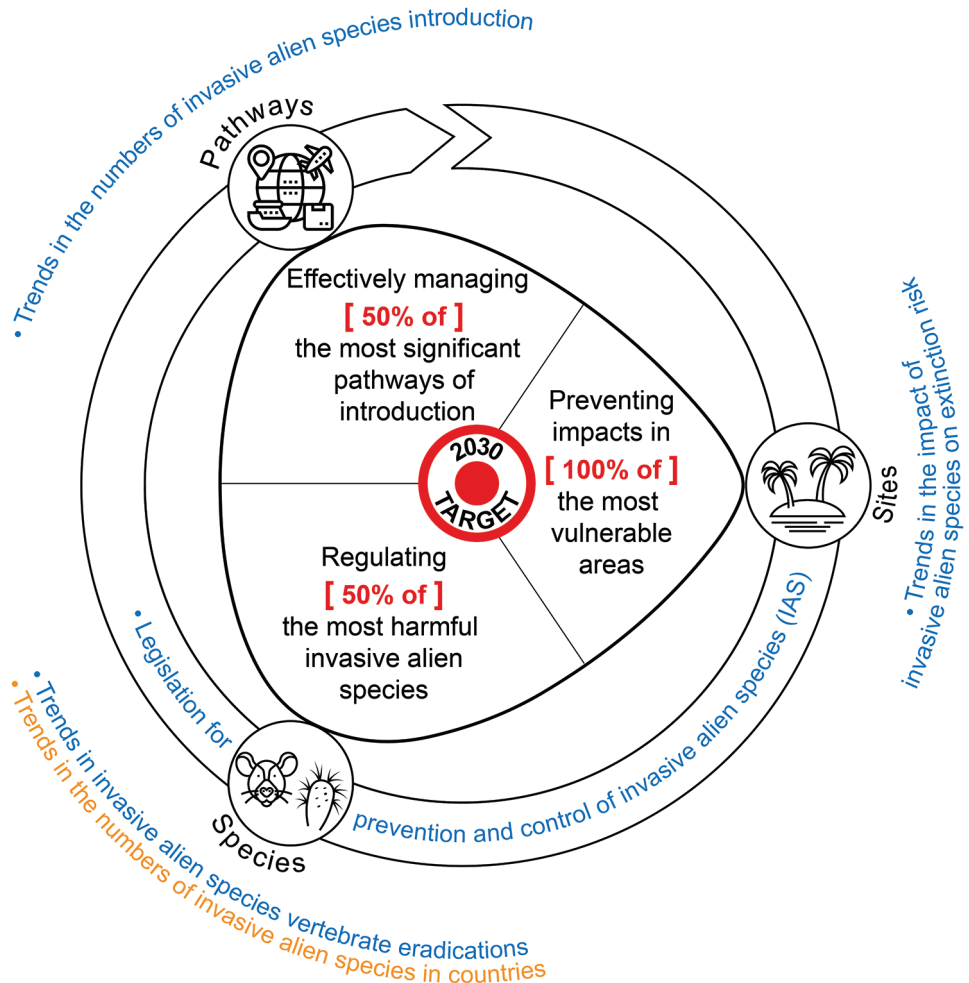


Figure 1. Proposed key components for an IAS target as part of the Post-2020 CBD framework. The components address the three inter-related components of pathways, species, and sites. Tentative quantitative targets are provided in brackets for 2030 [based on the proposal of the IUCN Invasive Species Specialist Group (ISSG), see Box 2], as a necessary step to achieve the management, regulation and protection of 100% of the most harmful IAS, the most significant pathways and the most vulnerable sites, by 2050 (Table 1). Bullet points indicate indicators for monitoring progress towards these targets. The text in blue indicates indicators used for the 2020 targets, and the text in orange indicates additional new indicators for the Post-2020 targets. Two icons made by Eucalyp from www.flaticon.com.

has documented that conservation efforts are inadequate to stop the loss of biodiversity and that IAS are one of the five major drivers of the current biodiversity crisis (Díaz et al. 2019). A ‘zero draft’ of the Post-2020 framework was published in early 2020, and carries forward the 2050 Vision “Living in Harmony with Nature” from the previous 2010–2020 strategy, which aims to reduce the rate of biodiversity loss, while securing food production and climate change mitigation (Leclerc et al. 2018). The ‘zero draft’

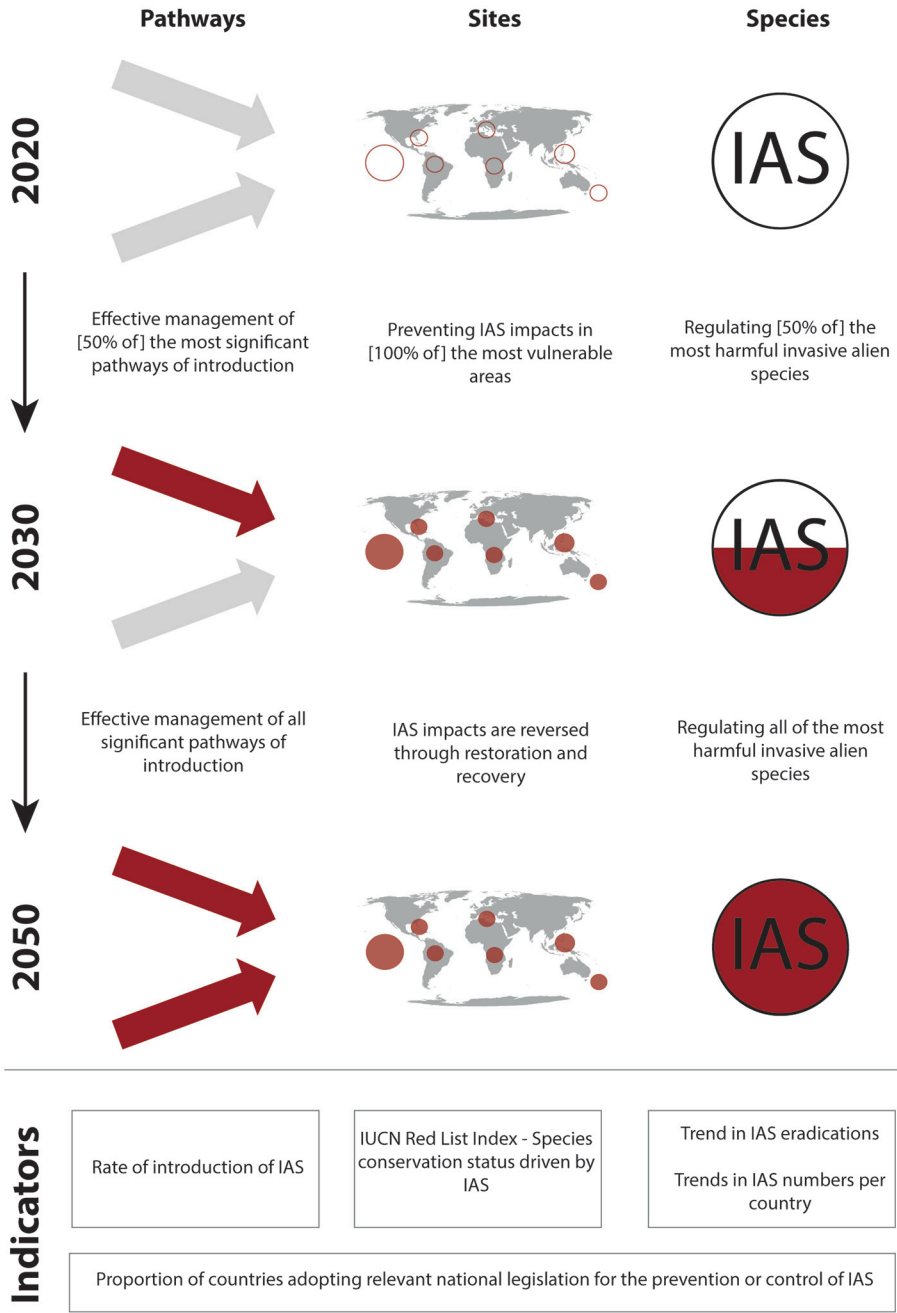


Figure 2. Schematic representation of the IUCN Invasive Species Specialist Group (ISSG) initial proposal of a post-2020 IAS target and the associated timeline. The target focusses on three key components – pathways, sites, and species (left to right) – and provides mid-term (2030) and long-term (2050) quantitative targets (cf. Table 1). For pathways, red arrows represent IAS pathways that are managed (50% in 2030 and 100% in 2050). For species the red area in the circle indicates the proportion of the most harmful IAS that are managed (50% in 2030 and 100% in 2050). For sites, filled red circles indicate priority sites that are managed (100% in 2030 and 2050). The proposed indicators to monitor progress are indicated at the bottom of the figure.

also sets out five goals for 2050, each with associated action-oriented targets for 2030 (CBD 2020). Target 3 is on IAS, and calls to ‘*Control all pathways for the introduction of invasive alien species, achieving by 2030 a [50%] reduction in the rate of new introductions, and eradicate or control invasive alien species to eliminate or reduce their impacts by 2030 in at least [50%] of priority sites*’ (CBD 2020). The exact formulation of this Target is likely to change due to ongoing discussions, and new drafts will be produced before being adopted at the 15th Conference of Parties to CBD.

In addition to Aichi Target 9 of the 2010–2020 Strategy, reducing the impacts caused by IAS has been recognised as a priority field of action by other global environmental policies. The United Nations Sustainable Development Goals (SDGs) contain a target on IAS which aims to “*prevent the introduction and significantly reduce the impact of IAS in terrestrial and water ecosystems and control or eradicate the priority species*” by 2030 (SDG 15.8). Progress is measured by the proportion of countries enacting relevant legislation and adequately resourcing IAS management and control (United Nations 2015, Egoh et al. 2020). Calls to action on IAS have been issued by the Intergovernmental Panel on Climate Change (IPCC) in its 5th Assessment Report (IPCC 2014). Following the first global assessment on biodiversity and ecosystem services (IPBES 2019), IPBES started a thematic assessment of IAS and their control in 2019, in response to the increasing recognition of the relevance of IAS to global biodiversity, ecosystem services and human livelihoods (https://ipbes.net/sites/default/files/ipbes-6-inf-10_en.pdf; final report due May 2023). The findings will be a highly relevant synthesis for future biodiversity policies of the state of knowledge of biological invasions and their impacts.

Essential properties of an IAS target

(i) It should consider the most significant pathways of introduction and their management

The paramount role of international trade and introduction pathways in shaping biological invasions and the impacts they cause is well understood (Essl et al. 2015; Seebens et al. 2015; Sardain et al. 2019). The transport and introduction of IAS can be intentional, e.g. for the pet trade or for ornamental horticulture, or unintentional, e.g. as stowaways on ships, planes, and vehicles or in the commodities carried by them (Hulme et al. 2008). The effective management of these pathways of introduction is critical to reduce future introductions. Intentional movements of species can be managed by regulating trade, import, possession, and transport; whereas unintentional (and to a large extent illegal intentional) movements first require the identification of their most important pathways of introduction. Prevention by managing pathways of unintentional introduction is particularly critical for marine and freshwater species and invertebrates, both because most such IAS arrive via unintentional transport (such as in ballast waters, as biofouling, and as soil contaminants), and because they are very difficult to control or eradicate once introduced. Managing key pathways of introduction for such IAS is feasible. For example, the International Convention for the

Control and Management of Ships' Ballast Water and Sediments (IMO 2014) which entered into force on 8 September 2017 includes targets (e.g. full global implementation by 2024) whose fulfilment would make significant progress towards stopping introductions via shipping (e.g. Bailey et al. 2011). Progress on biofouling, such as the GloFouling Project launched in 2018 (<http://www.imo.org/en/mediacentre/press-briefings/pages/20-biofouling.aspx>), could permit additional significant advances in the prevention of marine IAS introductions.

Similarly, several of the International Standards for Phytosanitary Measures (ISPM) developed by the IPPC (International Plant Protection Convention) specify measures to prevent the spread of pests and pathogens, including ISPM 03 (guidelines for the export, shipment, import and release of biological control agents and other beneficial organisms), 11 (pest risk analysis for quarantine pests), 15 (regulation of wood packaging material in international trade), 38 (international movement of seeds (as a commodity class)), 39 (quarantine pests associated with the international movement of wood, in particular those that infest trees), 40 (growing media in association with plants for planting), and 41 (used vehicles, machinery and equipment utilised in agriculture, forestry, horticulture, earth moving, surface mining, waste management and by the military) (FAO 2020). However, efforts on a similar scale are still largely lacking for most other pathways such as the illegal pet trade or eCommerce.

Pathway management and relevant targets and reporting are increasingly based on the pathway classification scheme adopted by the CBD (see Harrower et al. 2018 for guidance on its application). This scheme has, however, been criticised (e.g. Faulkner et al. 2020a), and it might be more appropriate to have tailored systems in place for particular contexts. For example, the traditional medicine trade has recently been highlighted as a potentially important introduction pathway for South Africa (Burness 2019). Such a pathway requires specific management interventions developed with the affected stakeholders, however it corresponds to three to four separate pathways in the scheme adopted by the CBD.

There is also a need to apply and adapt existing methods to monitor and control pathways after the initial introduction (secondary spread) (e.g. USDA APHIS, <https://www.aphis.usda.gov/aphis/home/>) in countries that do not yet have such systems in place (Zengeya and Wilson 2020), and between countries when intra-continental spread is important (Faulkner et al. 2020b). This secondary spread of IAS causes significant challenges as, in contrast to inter-continental movements of IAS which often rely on a few specific vectors, movements within a land mass can happen in many different ways, including by natural dispersal. Rapid response is therefore a major challenge for biosecurity.

(ii) It should take into account which species are the most harmful IAS

If the impact of IAS is to be reduced efficiently, it is essential to prioritise both the management of IAS that are currently most harmful, and those that are predicted to become the most harmful in the future. Recently, substantial progress has been made in under-

standing the global patterns and underlying causes of biological invasions, and in developing globally applicable tools for assessing their environmental and socio-economic impacts (Blackburn et al. 2014, Bacher et al. 2018, IUCN 2020). This was aided by recent compilations and analyses of global databases on the spatial distribution of alien species of various taxonomic groups (e.g. van Kleunen et al. 2015; Dyer et al. 2016; Capinha et al. 2017; Dawson et al. 2017; Pagad et al. 2018) and by analyses of the temporal trajectories of alien species accumulation (Seebens et al. 2017, 2018). However, predicting the impacts of IAS remains challenging (e.g. due to time lags, boom and bust-phenomena, and context specificity), and requires more research on understanding the processes leading to such impacts (e.g. Rouget et al. 2016; Strayer et al. 2017).

(iii) It should consider which sites (areas) are the most vulnerable to IAS

There is a need to identify and prioritise sites for management that are pivotal for biodiversity conservation (McGeoch et al. 2016). We believe that focusing global policy targets on regions that are particularly vulnerable to biological invasions is appropriate, as the largest biodiversity benefits can be accrued there. Islands and freshwater systems are particularly important as they often contain unique and highly threatened biota. Further, they are highly sensitive to invasions and IAS are the main cause of extinctions on islands (Bellard et al. 2013). Distant islands with high proportions of endemic and threatened species are the most invaded ones (Moser et al. 2018). IAS management on islands brings substantial biodiversity gains and ecosystem regeneration (Brook et al. 2007; Jones et al. 2016; Graham et al. 2018). For instance, eradicating invasive mammals from 100–200 high priority islands around the world would improve the survival prospects of many threatened species (e.g. Brooke et al. 2007; Dawson et al. 2015; Holmes et al. 2019). Recently, New Zealand has committed to eradicate by 2050 five highly invasive mammal species (three rat species, stoats, and possums) that are estimated to consume up to 26.6 million eggs and juveniles of native birds every year (Russel et al. 2015). Freshwater systems are similar in that they were historically isolated and are highly susceptible to invasions, such that IAS are a major threat to freshwater biodiversity (Dudgeon et al. 2006; Gallardo et al. 2015; Reid et al. 2019). However, the eradication of established freshwater IAS is often unfeasible, making prevention, pathway management and long-term population management critical.

Well-managed networks of protected areas are crucial for biodiversity conservation (Watson et al. 2014, Visconti et al. 2019) but biological invasions have substantial impacts in protected areas (Gallardo et al. 2017), which appear to be accelerating (Foxcroft et al. 2017). Consequently, IAS are a leading driver of biodiversity loss in terrestrial and aquatic protected areas worldwide (e.g. Bax et al. 2003; Kannan et al. 2013; Spear et al. 2013; Kearney et al. 2018). It is therefore essential to integrate IAS management into protected area management (Bax et al. 2003) such as it has been successfully done in the Kruger National Park (Foxcroft et al. 2008); however, dedicated resources are currently often insufficient (Braun et al. 2016).

(iv) It should contain quantitative policy targets

Several global environmental policy targets lack quantitative goals. Aichi Target 9 (along with the majority of Aichi Targets) does not include any quantitative scale of the desired reduction of impacts by IAS. The absence of quantitative targets can be detrimental for policy implementation and monitoring. Clear quantitative targets enable the development of policy options and actions that can be taken to reach or stay below the assigned thresholds (van Vuuren et al. 2012; IPBES 2016). In addition, quantitative targets can ease the communication of conservation goals to decision-makers and the general public. Thus, it has been increasingly recognised that quantitative policy targets are often preferable over qualitative ones. As an example in climate policy, a consensus was reached to keep global warming within specific boundaries of maximum mean annual temperature increase (e.g. 1.5 °C above pre-industrial times), which has been enshrined in the Paris Accord (UNFCCC 2015). Quantitative targets are therefore proposed within the ‘zero draft’ of the Post-2020 Framework, expressed as percentages of pathways, species, sites or other quantities to manage, including within the five overarching goals (CBD 2020). The significant progress in invasion science during the last decade now permits establishing evidence-based quantitative targets to be developed for the Post-2020 framework, that are scientifically sound, politically attainable, and for which progress can be assessed by monitoring existing or new IAS indicators (Burgman et al. 2014; Pergl et al. 2019; Latombe et al. 2017; Wilson et al. 2018). Furthermore, it will be important to recognise that the quantitative targets are global. Depending on the resources available, the risks faced, and the status of current invasions, the target that is achievable will likely vary significantly between countries and regions (cf. Box 3).

(v) It should define indicators to track progress

Standardised and accepted indicators on pathways, species, and sites are essential for monitoring the effectiveness of management with respect to the proposed target and for communicating progress to stakeholders and decision-makers. Indicators must assess changes of the status of interest over time. They should be easy to calculate, transparent, reproducible, robust, and meaningful, and they should not be restricted to a certain spatial scale. Indicators have been developed and used for specific functions, e.g. to track eradication campaigns (Holmes et al. 2019), measure the effectiveness of biological control programs (e.g. Klein 2011; Schwarzländer et al. 2018), and assess the status of biological invasions in World Heritage Sites (Shackleton et al. 2020). However, accepted indicators are needed to track progress towards the proposed target itself. Initiatives such as the sTWIST project (<https://www.idiv.de/de/sdiv/arbeitsgruppen/pool-of-working-groups/stwist.html>) are currently working on this issue.

Box 3. Reflections on the zero draft of the IAS target.

While the authors recognise that the IAS target in the ‘zero draft’ of the Post-2020 Framework is going to change based on ongoing negotiations, it is encouraging to see that the three main components of biological invasions – pathways, species, and sites – are reflected. However, we would stress the need to focus eradication and control upon **priority** IAS (based on their impacts), and that it is their **harmful** impacts that need to be reduced, especially in priority sites (e.g. islands, freshwaters) but also across continental habitats.

Importantly, the current target includes a clause that “impacts are reversed through restoration and recovery”. It is not clear, as yet, how this will be measured or monitored.

Many concerns were raised during the construction of the draft target. Here, we summarise some of the ideas based on comments raised by the ISSG members list server, and e-mail discussion with the IUCN ISSG. They are not comprehensive, but indicative, and have been rephrased as questions for consistency.

- Basic information on impact and pathways is not available for many countries / regions, perhaps gathering or collating this should be specified?
- Is there a need for an explicit call for data access and data sharing, particular between countries in a given region?
- Much of the problem is down to information and communication, so why are these not explicitly required in the target? Biosecurity often comes down to people’s behaviours.
- How do the targets incentivise proactive responses (contingency planning, early warning systems, and capacity to deal timeously with incursions)? Do priority species include both those that are currently widespread and those that will be threatening in future?
- Are researchers/scientists proposing interventions that can never be implemented? Maybe there is a need to be realistic about the target given that many of the necessary conditions, e.g. for effective biosecurity, are much broader than just IAS?
- Can managers be consulted as to the feasibility of these targets (financial, human capacity, infrastructure), and in terms of determining what factors are limiting their effectiveness? Currently, isn’t this rather a top-down approach?
- The targets might be appropriate for some countries and contexts, but are they right for others? Can targets better reflect the differences required to achieve them?
- For regulations to be effective, enabling conditions need to be in place. How can these be incentivised?
- Can the target be linked to the UN SDG goals? And the concept of “One Health”?
- Should trends in the spread of infectious diseases (for humans, plants and animal health) be included?
- Climate change will not just increase IAS incursions but also the trajectories of existing IAS (e.g. by changing the location of the climatically suitable ranges). How can shifts regarding which IAS are a priority be taken into account?
- How will we measure and monitor the extent to which impacts are reversed through restoration and recovery?
- What is the best way to focus eradication and control upon priority IAS (based on their impacts), and reducing their harmful impacts?
- How will we get the balance right between focussing on both priority sites (e.g. islands, freshwaters) and invasions of continental habitats?

Table 1. The components of the initially proposed IAS post-2020 target, and the proposed goals for the mid-(2030) and long-(2050) term perspective.

Element	Proposed activity	2030	2050
Pathway management	Managing the most significant pathways of introduction	50 %	100 %
Species prioritization	Regulating the most harmful IAS	50 %	100 %
Spatial prioritization	Preventing impacts in the most vulnerable sites	100 %	100 %
Restoration and recovery	Restoring degraded or heavily invaded ecosystems	To be decided	To be decided

(vi) It should be applicable to medium- (2030) and long-term (2050) time horizons

Quantitative targets are needed for 2030, although they might need refinement over time based on new data, and alignment with other targets. However, they should be seen as a ‘stepping stone’ for 2040 and 2050 where more visionary targets are included. Examples might be that by 2040 *all* harmful invasive alien species are regulated and *all* significant pathways of introduction effectively managed, and that IAS impacts are being reversed through restoration and recovery by 2050 (Table 1).

Potential indicators for measuring progress towards the proposed IAS target

Trends in the number of IAS introduction events

For monitoring the rate of introductions of alien species, the time series of IAS numbers now available for various taxonomic groups (Seebens et al. 2017, 2018) and regions (i.e. countries, islands) greatly assist the development of global indicators of alien species accumulation (McGeoch and Jetz 2019), although further research is needed to reduce existing sampling biases in space and time. Indicators should also cover aspects of invasion dynamics such as spatial extent, invasiveness, and impacts as well. Currently, new global indicators of biological invasions are under development (McGeoch et al. in prep.), which aim to obtain unbiased estimates of global and national introduced and invasive alien species richness, spatial extent, and degree of impact. These indicators ideally need datasets that follow the FAIR (Findable, Accessible, Interoperable, and Reusable) data principle (Wilkinson et al. 2016) to ensure comparability across regions and long-term availability. A restricted IAS dataset for just 21 countries was used as an indicator for Aichi Target 9 (GBO 2014).

Trends in the impact of IAS on extinction risk

The IUCN Red List Index on impacts of IAS is used as an indicator for Aichi Target 9. It shows trends in the conservation status (IUCN Red List, <https://www.iucnredlist.org>) of all birds worldwide driven only by the negative impacts of IAS or the positive impacts of their control (McGeoch et al. 2010, Genovesi et al. 2013). For a 2030 target, this indica-

tor should be broadened to include additional taxonomic groups (e.g. mammals, amphibians) that have now undergone multiple IUCN Red List assessments (Regan et al. 2015).

Trends in invasive alien vertebrate eradications

The Database of Islands and Invasive Species Eradication (DIISE, <https://www.islandconservation.org/diise-database>) compiles all known historical and current invasive bird and mammal eradications on islands, and should be used to track progress on IAS eradications.

Legislation, policy and regulations for prevention and control of invasive alien species (IAS)

This indicator should encompass the “Trends in policy responses, legislation and management plans to control and prevent spread of invasive alien species” and the “Proportion of countries adopting relevant national legislation and adequately resourcing the prevention or control of invasive alien species” (www.cbd.int/invasive). More specifically, it should measure a) national adoption of IAS-relevant international policy, b) percentage of countries with national legislation and policy relevant to IAS, c) national strategies for preventing and controlling IAS, d) national commitment (mandate and legal authority, cf. Fox et al. 2015) to key IAS related themes, and e) resourcing by national governments for the prevention and control of IAS as identified by the Sustainable Development Goals indicator 15.8.1 (<https://sdg.data.gov/15-8-1>).

Proposed new indicator: Trends in the numbers and impacts of invasive alien species in countries

The IUCN SSC Invasive Species Specialist Group working with partners under a mandate provided by Parties to the CBD, has developed the Global Register of Introduced and Invasive Species (GRIIS, <http://www.griis.org>), which will form a global baseline for trends in the numbers of IAS in countries, and their impacts where demonstrated impact has been recorded. The IUCN has endorsed the Environmental Impact Classification of Alien Taxa (EICAT) scheme (IUCN 2016), and developed a protocol for its implementation (IUCN 2020), see also Kumschick et al. (2020) for a discussion on its usage. EICAT provides an impact level category for each species based on its maximum impact globally and promises to complement information from the Red List (Van der Colff et al. 2020). Development of regional applications of the EICAT scheme (or of comparable risk schemes), regularly updated, would provide a tool to assess trends in impact of IAS. A framework has also been developed to address socio-economic impacts, the Socio-Economic Impact Classification of Alien Taxa (SEICAT) (Bacher et al. 2018), which is still to be extensively tested and proposed to the IUCN as a tool,

but will hopefully be used in concert with EICAT to broaden the consideration of the negative impacts of an IAS.

Relationship of the proposed IAS target with other policies

Relationship with other proposed Post-2020 Framework targets

Efforts to prevent and mitigate the impacts caused by IAS will also affect other goals and targets of the Post-2020 Framework; these goals include stopping the loss in the area and integrity of freshwater, marine, and terrestrial ecosystems, and reducing the percentage of species threatened with extinction. Considering the major effects of IAS on ecosystem degradation and species extinction, the IAS target should be ambitious enough to lead to the fundamental changes required to support the attainment of these goals and the 2050 Vision. The proposed measures should do this, and should also contribute to other targets, such as those aimed at retaining and restoring ecosystems of particular importance for biodiversity.

Relationship with existing regional and national policies

The new IAS target will only be achieved if subnational, national, and international policies are adequately implemented. Among such existing policies, the European Union (EU) Regulation 1143/2014 on Invasive Alien Species (EU 2014) fulfils Action 16 of Target 5 of the EU 2020 Biodiversity Strategy, as well as Aichi Target 9. It is accompanied by a set of implementation support documents targeting three aspects to promote its implementation: 1) prevention (introduction pathways and action plans), 2) management (measures and costs), and 3) early detection and rapid eradication (surveillance and identification). Relevant policies can also target specific, vulnerable regions, such as protected areas or Key Biodiversity Areas, as do the Council of Europe's guidelines on protected areas and IAS (Monaco and Genovesi 2013).

Biodiversity policies will only be efficient if supported by adequate resources. For example, the LIFE programme in Europe funds climate and environment actions, including many projects aimed at controlling IAS (<https://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=home.getProjects&themeID=96&projectList>). Other funding initiatives, such as the EU's Horizon 2020, will be essential for the acquisition and sharing of data.

Conclusions and outlook

During the writing of this article, negotiations on the nature and content of the Post-2020 Framework have continued with the goal that parties to the CBD will agree on its key components at their upcoming conference in Kunming, China, but the outcome

of the negotiations is unpredictable. While the socio-economic and political context is volatile, the key components that should be in the centre of global IAS policy will not change. Substantial progress in invasion science during the last decade allows, for the first time, the formulation of quantitative IAS targets that are informed by solid data, and which can be tracked by appropriate indicators. Measureable quantitative targets are also pivotal for developing targeted IAS management and policies.

The proposed properties that are essential for an IAS target are based on these advances, and they must be complemented by further instruments such as risk analysis, prioritization tools, decision support tools, cost-effective management tools, and efficient monitoring and evaluation systems. Further, community engagement and effective policy instruments are essential for successful implementation. We hope that these instruments, along with the list of proposed indicators, will support the negotiations towards finalizing an IAS target for the Post-2020 CBD framework. Whatever the final Target text is, achieving the fundamental changes necessary to prevent and mitigate impacts from IAS successfully over the coming decades will require substantial efforts and resources, and the cooperation of a wide range of stakeholders. The prevention of IAS impacts by precautionary measures and early response will avoid post-invasion costs and damages that are in many cases much – often by an order of magnitude – higher (Leung et al. 2002; Diagne et al. 2020).

Acknowledgements

This paper emerged from a workshop on ‘Frameworks used in Invasion Science’ hosted by the DSI-NRF Centre of Excellence for Invasion Biology in Stellenbosch, South Africa, 11–13 November 2019, that was supported by the National Research Foundation of South Africa and Stellenbosch University. We are grateful for the many helpful discussions we had with colleagues when developing and discussing the proposed IAS target for the Post-2020 CBD framework. FE, GL and BL highly appreciate funding by the BiodivERsA-Belmont Forum Project “Alien Scenarios” (FWF project no I 4011-B32). JR UW thanks the South African Department of Forestry, Fisheries and the Environment (DFFtE) for funding, while noting that this publication does not necessarily represent the views or opinions of DFFtE or its employees. HS acknowledges support from Belmont Forum-BiodivERsA project AlienScenarios through the national funders German Federal Ministry of Education and Research (BMBF; grant 01LC1807A). We appreciate the helpful comments of two reviewers, Alan Tye and Andy Sheppard, and of the handling editor, Julie Lockwood.

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